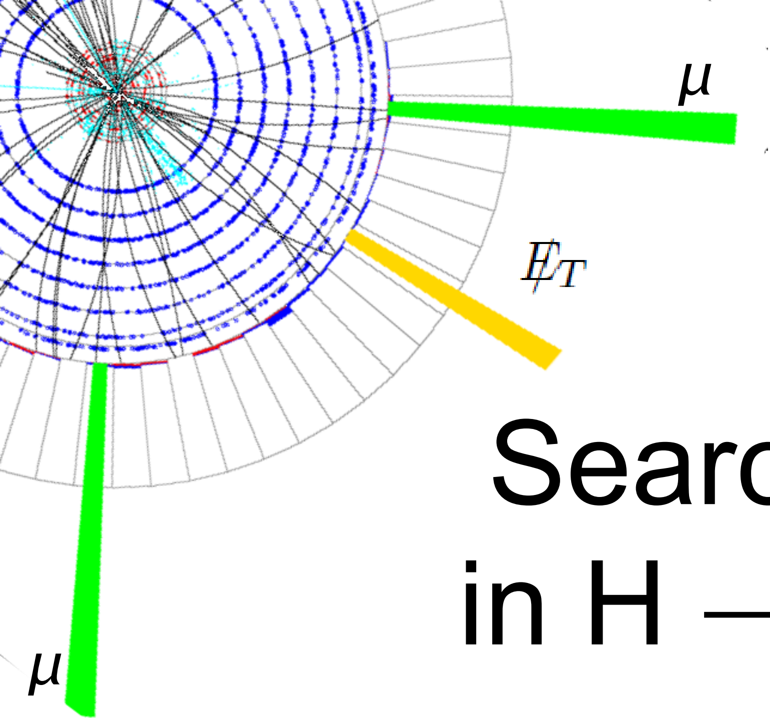

Young Scientist Forum
Rencontres de Moriond–EW
March 2010

Search for the Higgs boson in H → W W* → $l\nu l\nu$ decays

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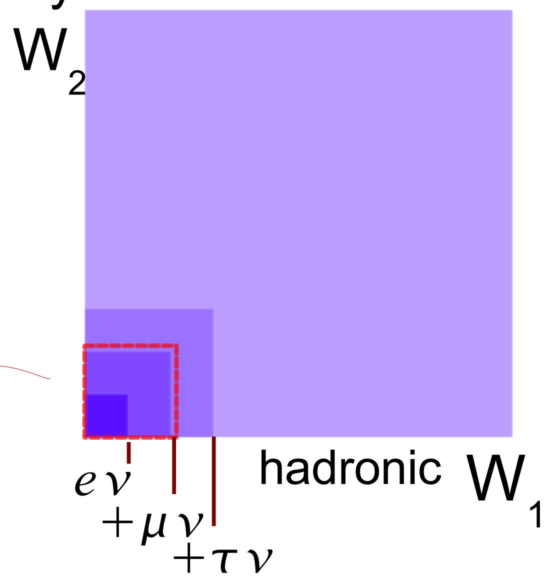
Princeton University

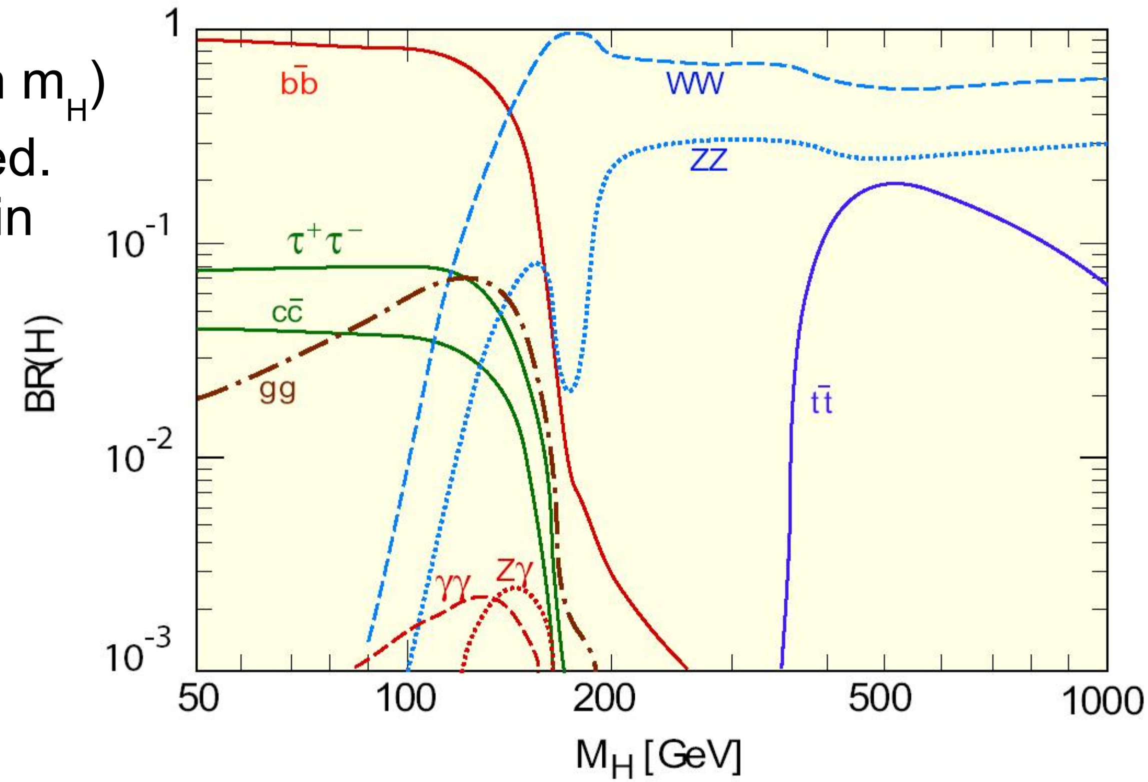
on behalf of the DØ collaboration

- Motivation
- Selection
- Multivariate Discriminant
- Limit

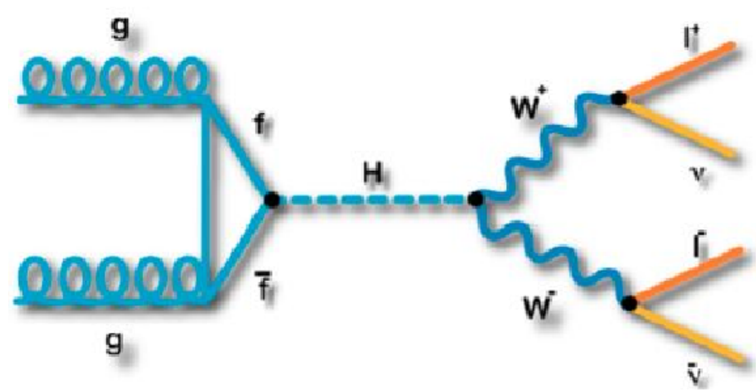
Motivation

This analysis: 5.4/fb
$\sigma(gg \to H)$=1.2-0.2 pb (depending on m_H)
$\to$ potentially O(1000) Higgs produced.
For a heavy Higgs ($m_H>2M_W$) the main decay channel is $H \to WW$





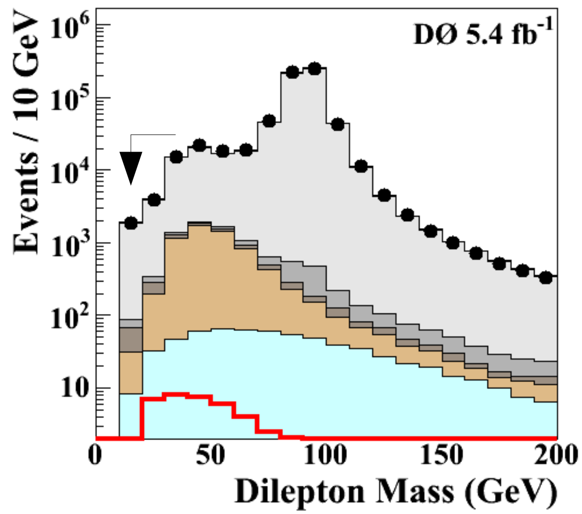
Consider the cases where both W's decay leptonically, leading to **ee**, **eμ**, or **μμ** with missing energy

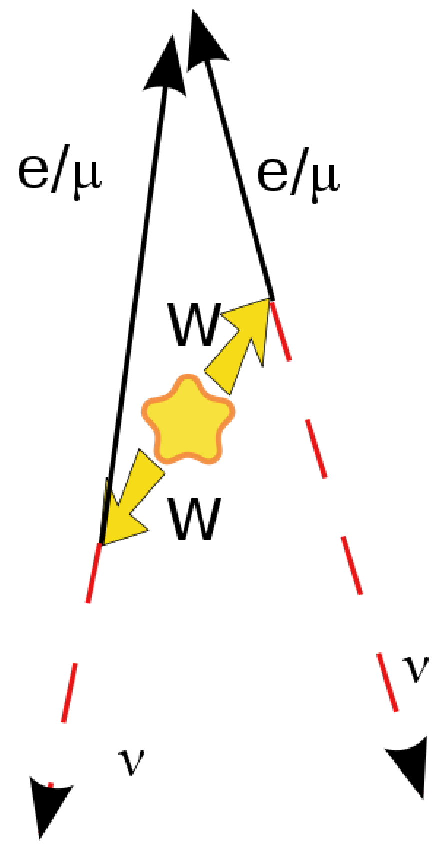


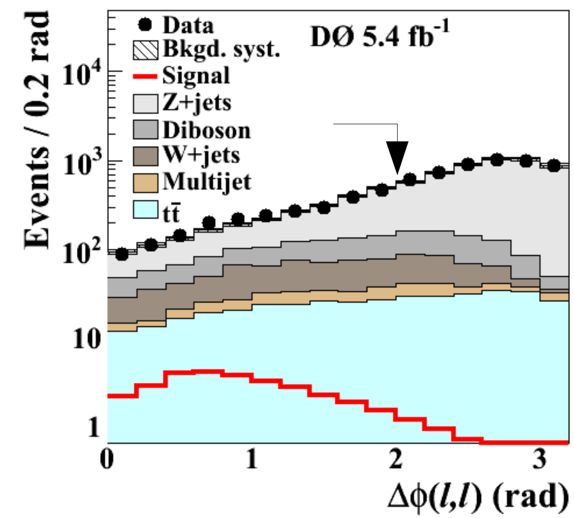
Final state with two high p_T leptons + missing energy: very clear signature

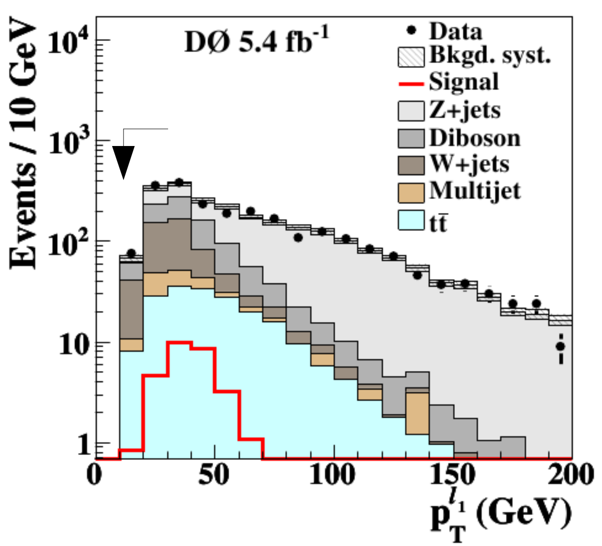
Event selection

First selection: events with two high p_T leptons (ee / eμ / μμ)

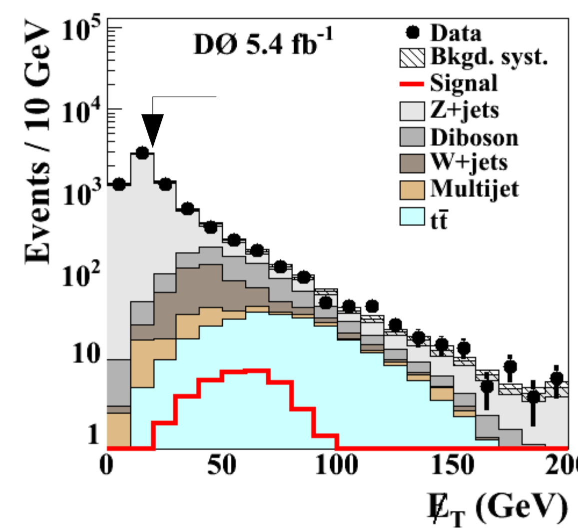




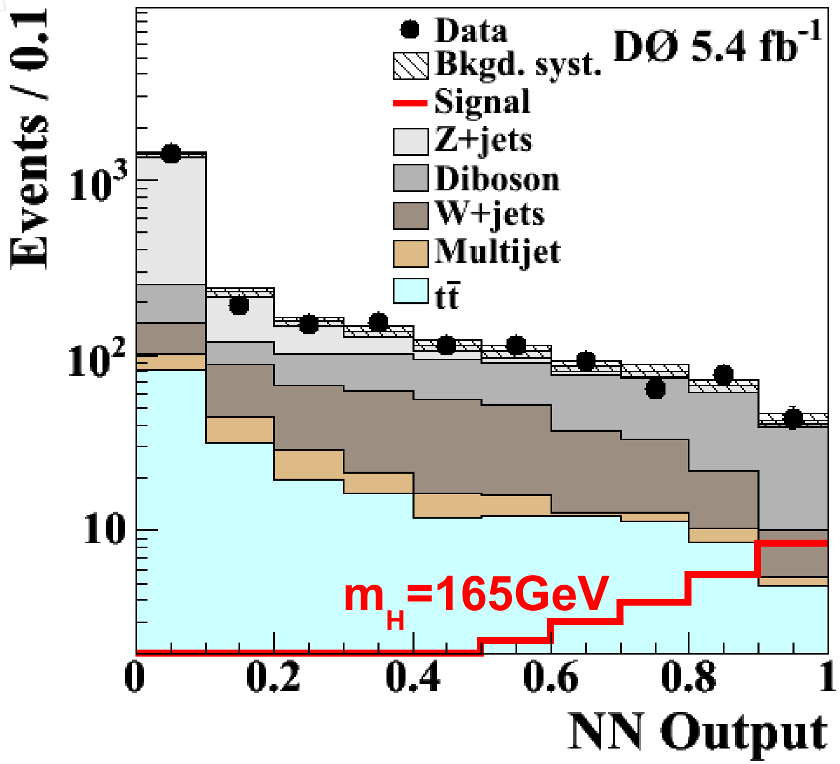




Then apply further cuts to reduce the backgrounds



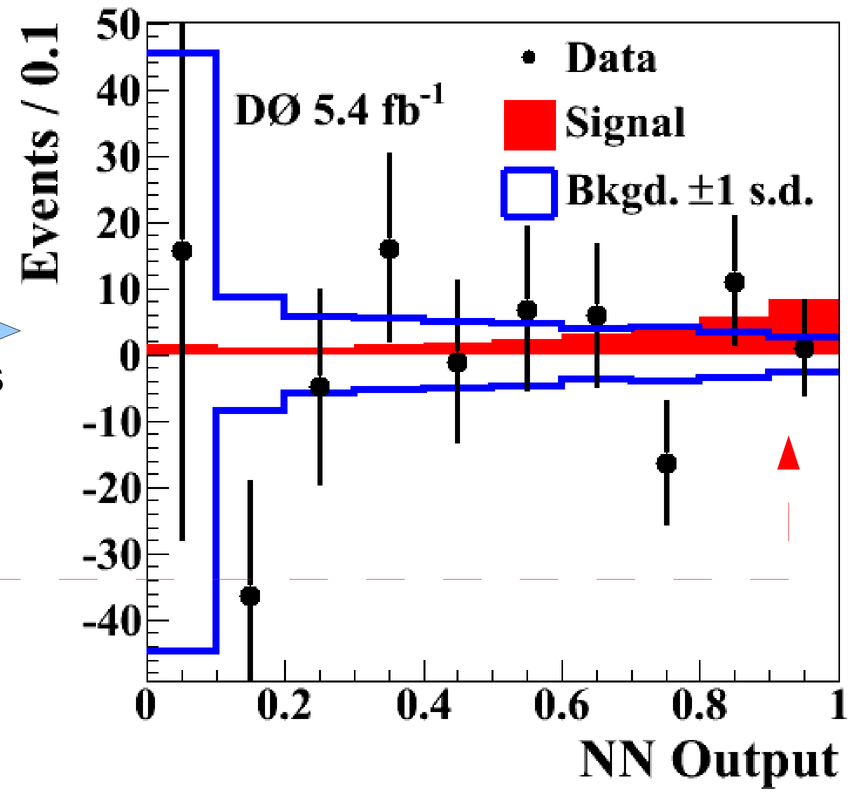
Final discriminant



Use a Neural Network (inputs: p_T, angles, M, MET, etc.).

Make sure that all of the variables are properly modeled, and train one NN for each value of the Higgs mass being considered.

Subtract → backgrounds



If there were a Higgs signal, it would be visible

No excess → set limits...

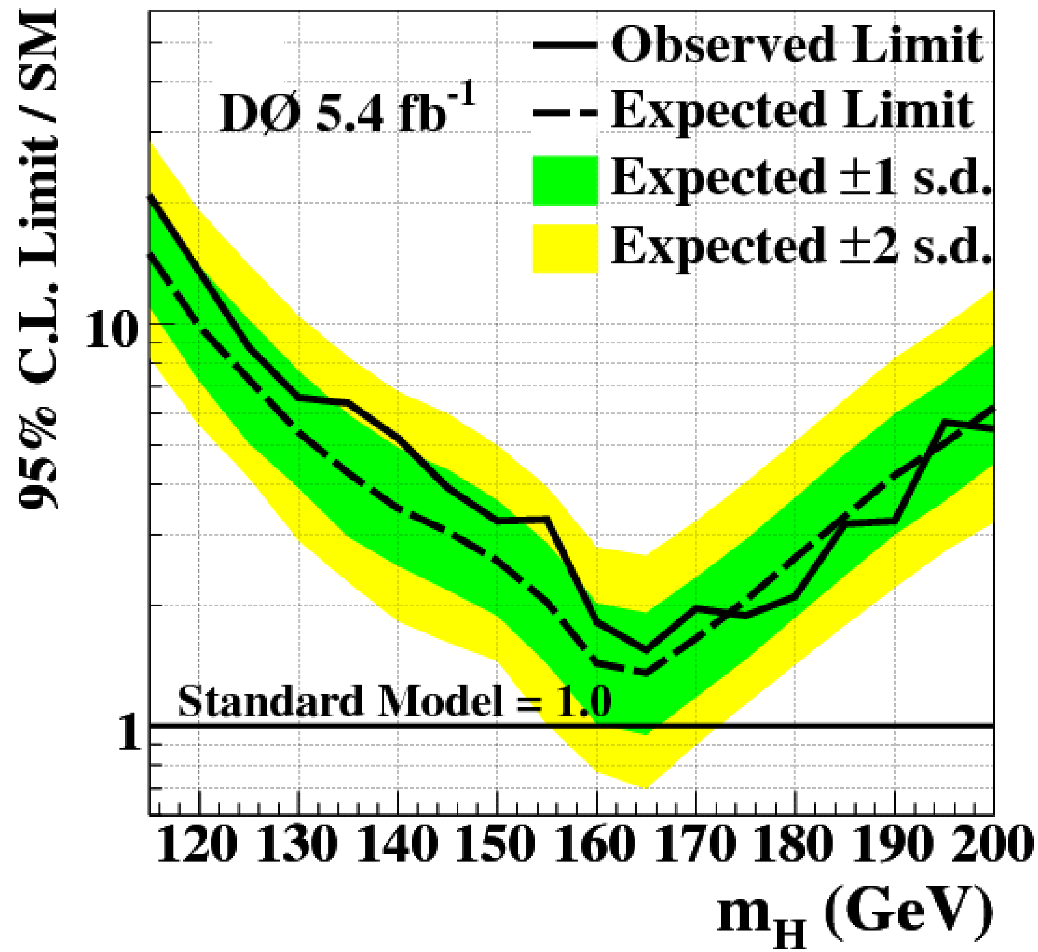
Limit setting

Phys.Rev.Lett. **104**, 061804

Report the limit at 95% CL that the data analyzed is not compatible with the SM prediction for Higgs production.

Take into account the following systematic uncertainties:

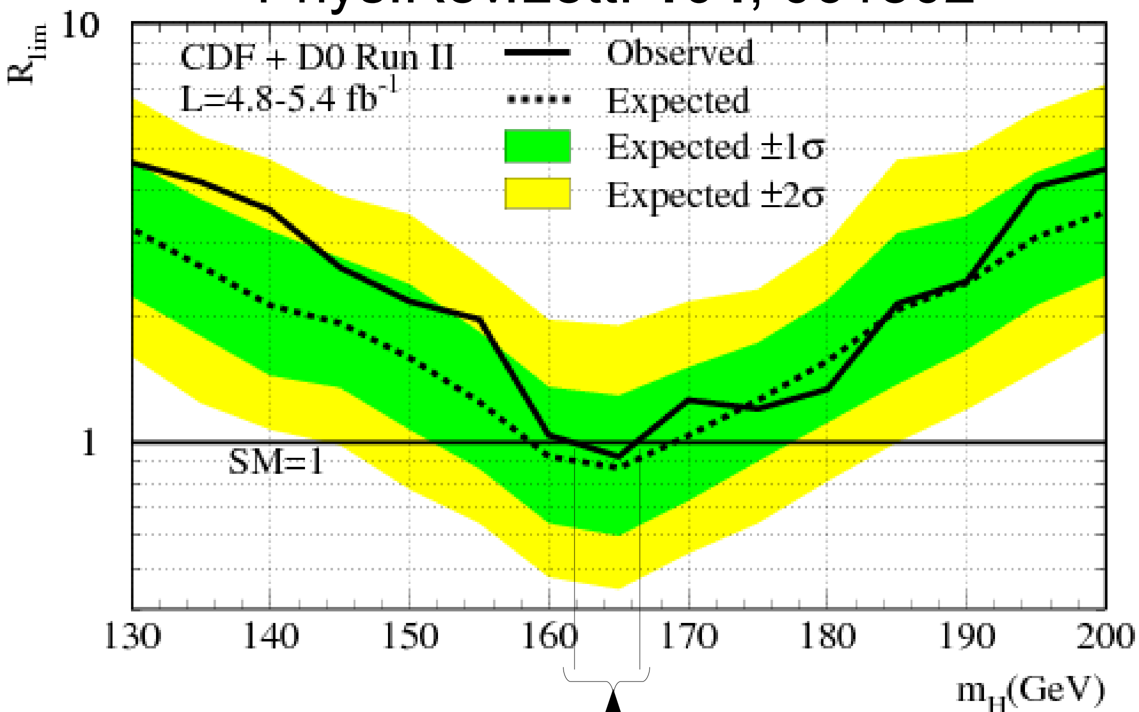
- theoretical cross sections
- lepton momentum calibration
- jet reconstruction efficiency and JES
- modeling of the p_T of H, WW, Z
- modeling of the multijet background
- ...



Conclusion

• Search for the SM Higgs at DØ in the channel H → WW → *lνlν* has been presented
• The combined CDF+DØ result provided the first exclusion of the Higgs boson at a hadron collider.
• Using L=5.4/fb, expect to double the analyzed dataset by the end of 2011, and to further improve our analysis techniques → Stay tuned!

Phys.Rev.Lett. **104**, 061802



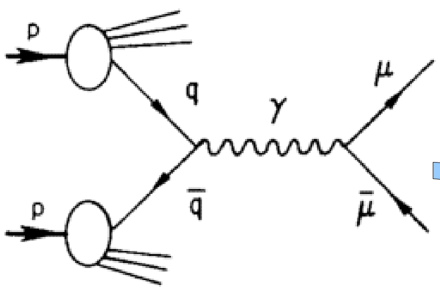
excluded

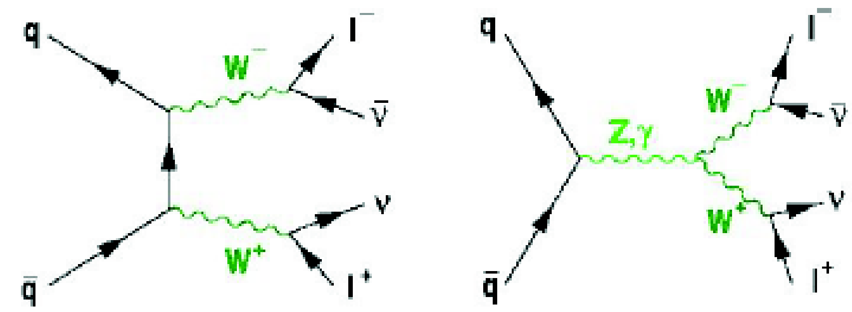
Thank you!

Backup

Backgrounds

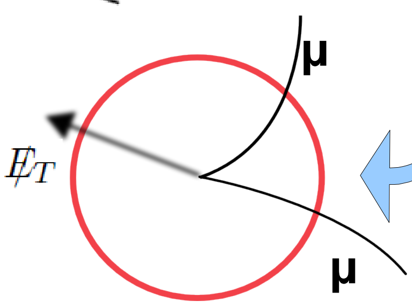
There are SM processes that can lead to the same dilepton+MET signature
- **intrinsic** background (same final state)
- **instrumental** background (similar f.s.)





WW production

A lepton with poorly measured p_T can mimic missing energy



Jets can be reconstructed as electrons (early showering, conversion)

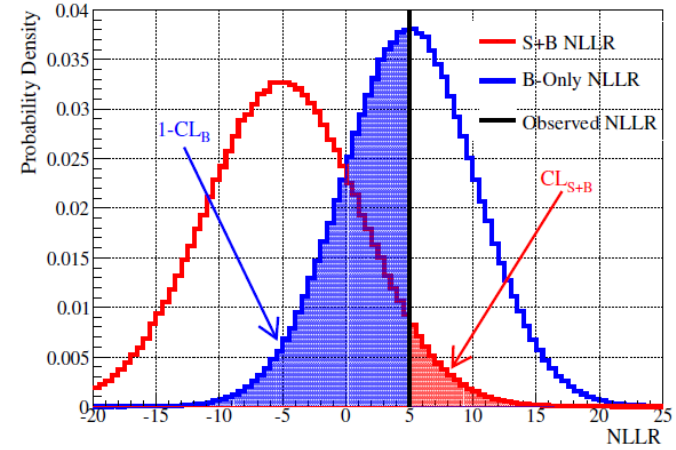
Backgrounds considered:
- **γ**/Z (+jets)
- W (+jets)
- diboson (WW, WZ, ZZ)
- top quark pair
- multijet

Alpgen

Pythia

Data

Limits setting

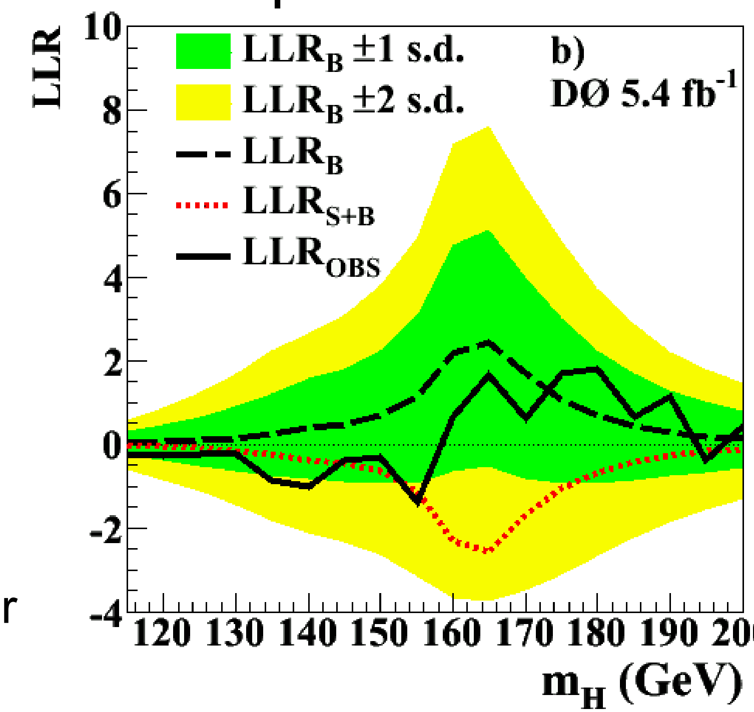


Test the background-only (B) and the signal + background (S+B) hypoteses using a Profile Likely Ratio test, as implemented in COLLIE (COnfidence Level LImit Evaluator).

Take into account the following systematic uncertainties:

- theoretical cross sections
- lepton momentum calibration
- jet reconstruction efficiency and JES
- modeling of the pT of H, WW, Z
- modeling of the multijet background

→ hep-ex/1001.4481

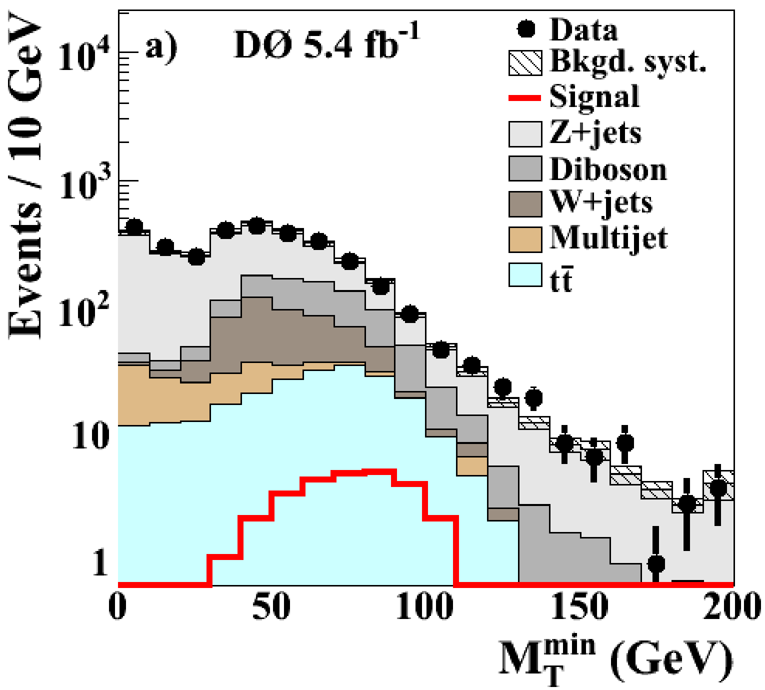


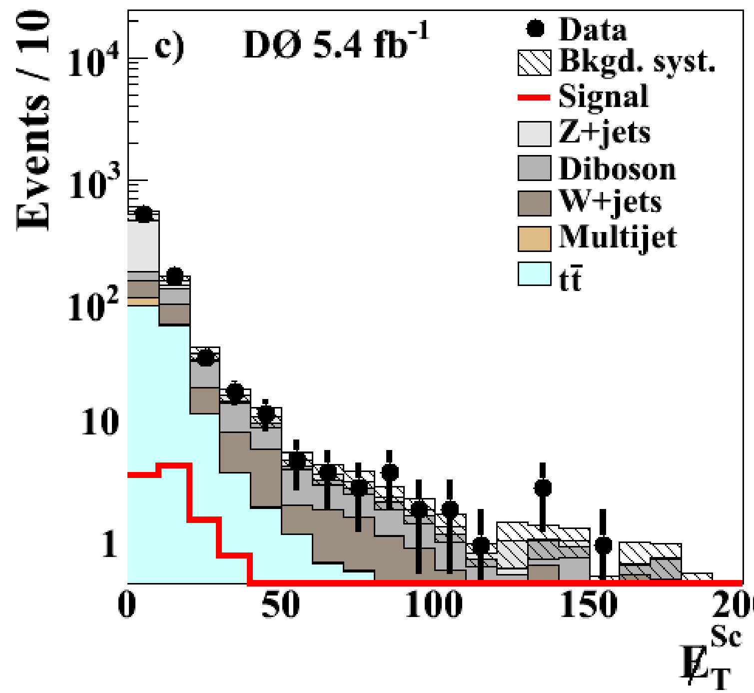
Generate two ensembles of pseudo-experiments for the two hypotesis, and using their probability distributions, compute the log-Likelihood-Ratio (LLR):

$$LLR = -2\ln \frac{\dfrac{e^{-(s+b)}(s+b)^d}{d!}}{\dfrac{e^{-b}b^d}{d!}}$$

Using the same formalism we can set determine the upper limit (1-CLs=95%) on the SM Higgs boson production.

Marginal distributions





Selection and NN details

Select events with two high p_T leptons:

- EM trigger (ee), inclusive trigger (em, mm)
- $p_T^e > 15$GeV, $p_T^\mu > 10$ (20) GeV
- opposite charge
- invariant mass > 15 GeV
- isolation (+separation from jets, ΔR>0.1, for μ)
- vertex within fiducial tracking region

$$M_T(l, \not{E}_T) = \sqrt{2 p_T^l \not{E}_T \left(1 - \cos\Delta\phi(l, \not{E}_T)\right)}$$

$$\not{E}_T^{\mathrm{Sig}} = \frac{\not{E}_T}{\sqrt{\sum_{\mathrm{jets}} \left(\Delta E^{\mathrm{jet}} \cdot \sin\theta^{\mathrm{jet}} \cdot \cos\Delta\phi\,(\mathrm{jet}, \not{E}_T)\right)^2}}$$

	ee	eμ	μμ
$\Delta\Phi(l_1, l_2)$	< 2.0rad	<2.0rad	< 2.0rad
MET	> 20GeV	> 20GeV	> 25GeV
$\mathrm{MET}_{\mathrm{Scal}}$	> 6 GeV	> 6 GeV	–
$\min(M_T)$	> 30GeV	> 20 GeV	> 20GeV

NN Analysis Variables	
Object kinematics	
p_T of leading muon	$p_T(\mu 1)$
p_T of trailing muon	$p_T(\mu 2)$
sum of the transverse momenta of the leptons(zpt)	$\vec{p}_T(\mu 1) + \vec{p}_T(\mu 2)$
number of VConf jets:	N_{VConf}
sum of the momenta of VConf jets:	$H_T = \sum_{VConf} p_T^{jet}$
minimal quality of one of the two leptons:	$\mathcal{Q}_{min}(\mu_1, \mu_2)$
Event Kinematics	
invariant mass of both leptons	$M_{\mathrm{inv}}(\mu 1, \mu 2)$
missing transverse energy	E_T^{miss}
minimum transverse mass	M_T^{min}
Topological Variables	
azimuthal angle between selected muons	$\Delta\phi(\mu 1, \mu 2)$
azimuthal angle between $\not{E}_T$ and the leading muon	$\Delta\phi(E_T^{miss}, \mu 1)$
azimuthal angle between $\not{E}_T$ and the trailing muon	$\Delta\phi(E_T^{miss}, \mu 2)$
log base 10 of the sum of the scaled isolations for the two muons	

Cutflow

TABLE I: Expected and observed event yields in each channel after preselection and at the final selection. The systematic uncertainty after fitting is shown for all samples at final selection.

	$e^{\pm}\mu^{\mp}$		$e^{+}e^{-}$		$\mu^{+}\mu^{-}$	
	preselection	final selection	preselection	final selection	preselection	final selection
$Z/\gamma^{*} \rightarrow e^{+}e^{-}$	120	< 0.1	274886	158 ± 13	–	–
$Z/\gamma^{*} \rightarrow \mu^{+}\mu^{-}$	89	4.3 ± 0.3	–	–	373582	1247 ± 37
$Z/\gamma^{*} \rightarrow \tau^{+}\tau^{-}$	3871	7.1 ± 0.5	1441	0.7 ± 0.1	2659	12.0 ± 0.7
$t\bar{t}$	312	93.8 ± 8.3	159	47.0 ± 4.4	184	74.6 ± 6.8
$W + \text{jets}/\gamma$	267	112 ± 9	308	122 ± 11	236	91.5 ± 6.5
WW	455	165 ± 6	202	73.9 ± 6.4	272	107 ± 9
WZ	23.6	7.6 ± 0.2	137	11.5 ± 1.0	171	21.5 ± 2.0
ZZ	5.4	0.6 ± 0.1	117	9.3 ± 0.9	147	18.0 ± 1.8
Multijet	430	6.4 ± 2.5	1370	1.0 ± 0.1	408	53.8 ± 10.3
Signal ($m_H = 165$ GeV)	18.8	13.5 ± 1.5	11.2	7.2 ± 0.8	12.7	9.0 ± 1.0
Total background	5573	397 ± 14	278620	423 ± 19	377659	1625 ± 41
Data	5566	390	278277	421	384083	1613

Template